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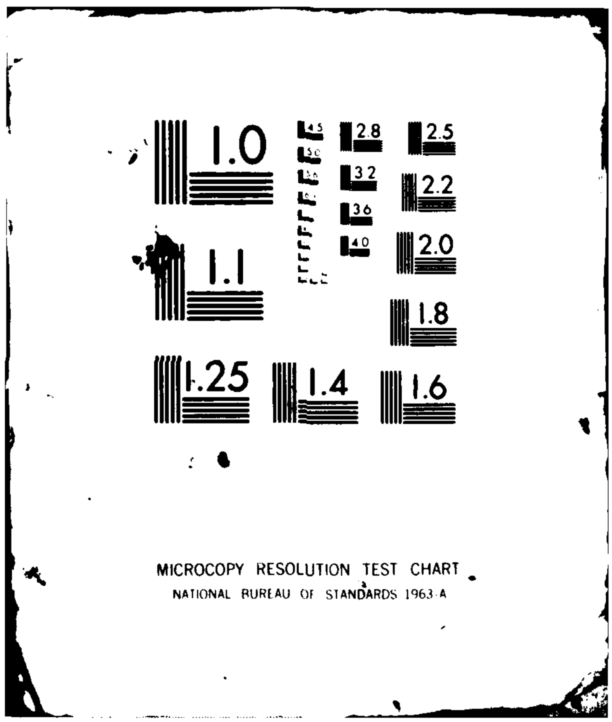
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MELBOURNE, VICTORIA

AERODYNAMICS TECHNICAL MEMORANDUM 324

PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLATION: PART 8 : PROGRAMS FOR PROCESSING DATA ON THE CENTRAL SITE COMPUTER

B.D. FAIRLIE

Approved for Public Release.

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by

B.D.Fairlie

SUMMARY

Three programs which run on the central site computer (PDP-10) are described. The first, PLT8 complements and extends the tunnel installation six-component force data plotting system. The second, INTEG integrates aerofoil surface pressure measurements. The third, PLTALL plots these surface pressure data.

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16. ABSTRACT:

Three programs which run [illegible] central site computer (PDP-10) are described. The first, PLT8 complements and extends the tunnel installation six-component force data plotting system. The second, INTEG integrates aerofoil surface pressure measurements. The third, PLTALL plots these surface pressure data.

CONTENTS

1. INTRODUCTION

The Transonic Wind Tunnel (PDP-8/I) Data Processing Installation is primarily intended to perform on-line collection and reduction of wind tunnel data, and printing and plotting of results. Earlier memoranda in this series [1,2,3,4,5] #1 have been devoted to these functions. In most cases, this installation can provide results in a form suitable for incorporation in reports or for communication to a requesting authority. However, the need occasionally arises for further computation to be carried out on the data. This may involve extensive interpolation or extrapolation of results or cross plotting of results, for which there is insufficient storage capacity available on the PDP-8/I. In these cases it becomes necessary for data gathered by the tunnel installation to be transferred to the central A.R.L. PDP-10 computing system for further processing.

This memorandum describes three programs which operate on the PDP-10 and process data generated by the Transonic Tunnel PDP-8/I system. The first, PLT8 is a general program for plotting six-component force data. The program complements and extends the plotting capability of the tunnel installation, providing the ability to produce plots of interpolated and cross plotted data and static derivatives, for which the amount of core memory currently available on the PDP-8/I is not sufficient. The second program, INTEG carries out integration of aerofoil surface pressure measurements. This program includes a sophisticated system of parameter specification which enables the user to add some of his aerodynamic experience to the information included in the data itself. This program also produces listing files in a form suitable for inclusion in publications, and an intermediate file which is of a form suitable as input to the third program, PLTALL. PLTALL is designed to produce plotted output of both experimental and theoretical pressure distributions. It has extensive facilities for overplotting, changing symbolism and labelling of overplotted data sets.

In writing these programs an attempt has been made to keep them as general as possible, so as to include as many of a users needs as possible in a small number of programs. This has led to some degree of complication in some parts of the guides to running the programs included in this memorandum, but the programs have generally been written in an interactive manner so that their interpretation is usually quite clear to the user who knows what he wants to do.

The memorandum is written in three distinct sections, one on each program. Each section has been kept as complete as possible so that the user may read just the section on the program of interest and obtain a complete understanding of that program without needing to read the complete publication. This has led to some duplication in the explanation of some procedural matters, but should make the publication of more general use.

#1Numbers in square brackets refer to references listed at the end of the memorandum.

2. PROGRAM PLT8

2.1 INTRODUCTION

PLT8 is a program for plotting six-component force data produced by the Transonic Wind Tunnel data processing (PDP-8/I) system. It complements and extends the data plotting system of that installation, producing output plot files of a similar form. It extends the capabilities of that system by enabling the user to plot almost any reasonable combination of the seventeen output variables produced by the six-component force system. In addition it is able to produce plots of the six most commonly used static derivitives against Mach number. It differs from the installation plotting routines in that extensive use of interpolation and extraploation is made in producing cross plotted results, so that the user can produce a plot of, for example, pitching moment coefficient versus Mach number at constant values of lift coefficient, even though tests were carried out at discrete values of angle of incidence.

The final output plots are produced with the "horizontal" axis across the plotting paper and the "vertical" axis along the plotting paper. Facilities are provided for plotting a set of data on more than one set of axes, and for overplotting one set upon another, with facility for changing symbols, the symbols of each set being labeled. Further extensions to the tunnel plotting routines are the provision of facilities to plot fitted curves through the data, the fitting being achieved with exact piecewise cubics, and for the addition of headings to each plot. Examples of the plotted output of the program are shown in Figures 1 & 2.

The program is intended to be used in those cases in which the required plotting facility is not available on the tunnel installation, or where a set of data has to be recomputed on the PDP-10, in which case retransfer back to the PDP-8/I is not necessary.

The following guide to running the program reflects the software as at March 1980.

2.2 RUNNING THE PROGRAM

Assuming that the file PLT8.EXE is resident on the user's Disk area (if not, a version may be obtained from DECtape D/868) the program is run by the command

RU PLT8

The program begins by typing the heading

<u>TRANSONIC TUNNEL DATA PLOTTING PROGRAM</u> (1) #2

#2Numbers in brackets refer to step numbers.

The program then requests information about the type of axes required by typing

AXES ON TWO SIDES ONLY (Y OR N) ? (2)

A Y (yes) reply will produce axes drawn on the bottom and left hand side of the plot only, with tick marks and scale included. The program then transfers to step (3). An N (no) response will produce

PLOT A 1" GRID (Y OR N) ? (3)

An N (no) response here will cause axes with tick marks to be drawn on all four sides of the plot, with scales on the bottom and left hand sides as in Figure 1. A Y (yes) response will give a similar axes set but with a 1" grid joining the tick marks as shown in Figure 2. These settings for the type of axes will remain in force for all plots produced until the program is restarted. For steps (2) and (3), as for all other program requests with a Y or N option, a reply of any character other than Y or N will cause the question to be repeated.

The program then requests an output file name to receive the plot files.

TYPE OUTPUT (PLOT) FILE NAME : (4)

The user replies by typing any valid PDP-10 format file name consisting of a 1 to 6 character file name followed optionally by a full stop (".") and a 1 to 3 character extension. The program then requests an input file name from which the data are to be obtained.

TYPE INPUT (DATA) FILE NAME : (5)

The file name is of the same form as that for step (4). The format of this file is given in Appendix A. The input file is most easily generated by transferring six-component force data from a PDP-8 DECtape to a PDP-10 DECtape using DOUT and CP10 [6] . The program then types

CONSTANT ALPHA BETA OR M (A, B, OR M) ? (6)

and expects a reply of A, B, or M depending on whether the data in the input file are in groups of constant incidence, sideslip, or Mach number. Note that the limits for accepting Mach numbers as being the same nominal value is set to +/-0.005 and the limits for both incidence and sideslip are +/-0.2. If the reply is not one of A, B, or M the request will be repeated until a satisfactory reply is obtained. The program then types

TYPE DEPENDENT VARIABLE (VERT. AXIS) : (7)

which expects a reply of one of the seventeen valid variables which the user wishes to be plotted on the vertical axis. Similarly

TYPE INDEPENDENT VARIABLE (HOR. AXIS) : (8)

expects the name of the variable the user wishes to be plotted on the horizontal axis. An illegal variable name (e.g. XXX) typed as a reply to either (7) or (8), will invoke a request to try once again, together with a list of valid variable names, thus

```
VARIABLE "XXX" NOT IN LIST:
VALID VARIABLE NAMES ARE:
M ALPHA CL CM CD CZ CX CLSQ CXB ALPT BETA
CC CN C1 PHI CY DCLAL DCZAL DCLCM DCNBT DC1BT DCYBT
```

TRY AGAIN:

If the reply to (7) was one of the available derivatives (the last six in the above list) the program's reaction is somewhat different. The program will firstly request information about the type of curve fitting to be used in forming the derivatives.

LEAST SQUARES STRAIGHT LINE (S) OR EXACT PIECEWISE
CUBIC (C) FOR FINDING SLOPES (S OR C) ? (9)

The choice of curve fitting type has been left open to the user since neither type has been found to be entirely satisfactory in all cases. Since at present all derivatives may only be plotted against Mach number, the request for input of an independent variable (8) will not appear, the program assuming "M" and typing

NOTE: SLOPES MAY ONLY BE PLOTTED AGAINST M
M HAS THEREFORE BEEN MADE INDEPENDENT VARIABLE (10)

The program then types

TYPE VARIABLE TO BE HELD CONSTANT : (11)

and expects the name of the variable the user wishes to be held constant for each individual curve plotted (i.e. the variable to be taken as the parameter of each set of plotted curves). Again an illegal variable name will invoke the try again sequence.

The program then requests information about the number required and the values of this parametric variable. There are two cases to be considered:

-if the parametric variable is the same as the group constant (i.e. incidence, sideslip, or Mach number), the program asks

ORDER OF XXX'S AS IN DATA FILE (Y OR N) ? (12)

A Y (yes) reply will plot curves with constant values of XXX in the order in which they are found in the input data file, and the program will jump to step (15) or (18).

-if this is not the case, or if the reply to step (12) is N, the next response enables the user to specify the required number and values of the parametric variable.

TYPE NUMBER OF VALUES OF XXX (</=20) (13)

The program expects a decimal integer reply (N) of the number of values required (maximum of 20 values). This is followed by

XXX(1) =
XXX(2) =
.
.
.
XXX(N) = (14)

which expects signed decimal floating point numbers, being the corresponding required values.

The data will then be read in from the input file. Any illegal character found in the input file will terminate execution and the line of the input file containing the offending character to be printed on

the terminal, with an up-arrow (^) indicating the position of the illegal character.

If the data is read in successfully the next step is to fix the scales of the two axes,and the program will type step (15). If however the independent variable was one of the available derivatives and the reply to step (9) was "S" (indicating a least squares straight line fit for slope determination) the program will now provide an opportunity for the user to specify the range over which the slope is to be calculated (i.e. the limits of the straight line fit).

TYPE RANGE OF CC OVER WHICH SLOPE TO BE CALCULATED (15)

FOR CC = XXX(1)
CC MIN = (16)

Here CC is the parametric variable specified at step (11) and XXX(1) is the first value of CC input at step (14). The program expects a signed decimal floating point number corresponding to the minimum value of CC to be included in the slope calculation for this value (XXX(1)) of CC. This is followed by

CC MAX = (17)

where the corresponding maximum value is input. Steps (16) and (17) are repeated for each of the N values of CC entered at step (14).

Note that if at any time when fitting least squares straight lines to the data, the limits input at steps (16) and (17) are such that less than two data points are included within the range, the program will type

*** ATTEMPT TO FIND L-S SLOPES USING LESS THAN TWO POINTS !
*** PLOT ABORTED ***

and execution will be terminated. If only two data points are included in this range, the warning message

L-S SLOPE ROUTINE HAS FOUND ONLY 2 POINTS IN STATED RANGE
EXACT STRAIGHT LINE WILL BE FITTED

will be typed, but execution continues. A similar warning message

CAUTION: ATTEMPTED INTERPOLATION WITH TWO OR LESS POINTS
.... ERRORS WILL PROBABLY RESULT

is typed in the cubic polynomial fitting process (which is used for all interpolation as well as slope finding with a "C" reply to step (9)). Once again execution continues but the user is warned to check the resulting plot carefully since results are unpredictable.

Once steps (15) to (17) are completed, or if the reply to step (9) was "C", the program types

MACHINE SCALING REQUIRED (Y OR N) ? (18)

A Y (yes) reply will indicate that suitable scales are to be generated by the program from a consideration of the ranges of the input data. The next response will then be step (24). An N (no) reply allows the user to specify his own plotting scales, and the program will type

HHH AXIS :
MINIMUM = (19)

where HHH is the previously selected independent variable, and the program expects a signed decimal floating point number corresponding to the minimum scale calibration required on that axis. This is followed by

INCREMENT/INCH = (20)

which expects an unsigned decimal floating point number being the increment per inch of axis of the scale calibrations. Similar replies are expected for

VVV AXIS :
MINIMUM = (21)

where VVV is the dependent variable, and again

INCREMENT/INCH = (22)

The program then requests

LENGTH OF AXIS (INCHES) = (23)

expecting an unsigned decimal floating point number indicating the length in inches of the vertical axis. (Note: The length of the horizontal axis is fixed at 10.0 inches). The program then types

TYPE NUMBER OF PLOTS PER PAGE : (24)

and expects a decimal integer reply (greater than zero !) of the number of individual curves to be plotted on each set of axes.

SHIFT AXES (Y OR N) ? (25)

is the next program output. If a vertical shift between successive curves is required, a Y (yes) reply will produce a request for the size of the shift required

TYPE SHIFT (INCHES) : (26)

as an unsigned decimal floating point number of inches. A N (no) reply to step (25) will jump to step (27) or (28).

If machine scaling was requested the program selected scale factors will now be printed. Otherwise the next program response will be step (28).

MACHINE SCALING FATORS:
HHH AXIS:
MINIMUM = x.xxx
INCREMENT = x.xxxx/INCH
VVV AXIS:
MINIMUM = x.xxx
INCREMENT = x.xxx/INCH
LENGTH OF AXIS = x.xxx INCHES (27)

where once again HHH and VVV are the selected independent and dependent variables respectively.

The next response determines whether a fitted line is to be drawn through the data points as well as symbols being plotted.

PLOT FITTED CURVE (Y OR N) ? (28)

A Y (yes) reply will cause a fitted line to be drawn through every data point with its shape determined by a local piecewise cubic polynomial fitting routine. An N (no) reply will plot symbols only, the centroid of each symbol coinciding with the data point position. The next program response

HEADINGS REQUIRED (Y OR N) ? (29)

allows the user to type in any text information required to identify the plot. This information will be plotted below the horizontal axis at the bottom of the plotted page, each line being centred horizontally on the page. A Y (yes) reply will produce

TYPE IN UP TO 5 LINES OF UP TO 72 CHARACTERS EACH
FIRST CHARACTER OF LAST LINE AN ^ (30)

Each line should end with a CR/LF. Note that no more than three consecutive blank characters should appear since the program uses such a sequence to recognise the end of valid information in a line. The ^ (up arrow) should be typed as the first character of the line following the last line of text required, and should be followed by a CR/LF. The ^ is not required if all five available lines of text are utilised.

At this stage the actual plotting of axes, points, headings, etc. takes place. On completion the program will type

ANOTHER FILE TO BE PLOTTED (Y OR N) ? (31)

An N (no) response will terminate program execution and the plot files produced may be sent to the plot queue for plotting (see Appendix B for details of the operation of the program PLOTQ). A Y (yes) response brings a request for information as to which, if any, of the parameters relevant to the plot just completed should be retained for the following plot.

ON THE SAME SET OF AXES (Y OR N) ? (32)

A Y (yes) reply here will cause the data from the next data file to be overplotted on the axes just drawn. Variable assignments, scales, and headings will all remain the same. The user is however given the opportunity at this stage to change the symbol set for the data to be overplotted to aid in distinguishing between data sets. The program will therefore type

SAME SYMBOL FOR EACH VALUE OF XXX (Y OR N) ? (33)

where XXX is the name of the parametric variable input at step (11). A Y (yes) reply will leave the symbol set unchanged, and steps (34) to (36) will be omitted. An N (no) reply will increment the entry in the symbol table by a number equal to the number of values of XXX, so that each curve will have a distinct symbol. The table at the bottom of each page showing the relationship between the symbols and the values of XXX will be duplicated for each new set (see for example Figure 2). To enable the user to label these tables, the program types

LABEL EACH SET (Y OR N) ? (34)

An N (no) reply transfers to step (37). A Y (yes) reply initiates a check to see whether the number of values of XXX is too large to fit in the space allocated for the symbol tables. Currently, if there are more than 8 values of XXX per page, the program will type

TOO MANY VALUES IN SET FOR SUCCESSFUL LABELLING ! (35)

and the program transfers to step (37) or (38). If sufficient space is available the program types

TYPE LABEL FOR LAST SET (MAX. 15 CHARS.)
END WITH A CR (36)

and any legal character string may be input as a label. If more than 15 characters are typed, those after the 15th will be lost. If a fitted curve has been specified for the first data set, the program will now type

CHANGE FITTED CURVE LINE TYPE (Y OR N) ? (37)

A Y (yes) reply will increment the line type table entry by one, and the new set of data will have a line fitted of the new type. Currently the line type table entries are:-

(1) continuous line
(2) short dashed line
(3) short/long/short dash sequence
(4) short/short/long/short/short dash sequence
(5) long dashed line
(>5) long dashed line

The program automatically takes account of the slope of the fitted line so as to maintain long and short dashes of the same mark/space ratio throughout the curve.

The only other information requested by the program will be an input file name (step(4)), and the next response will be step (31).

An N (no) response to step (27) will produce

THE SAME SET OF VARIABLES (Y OR N) ? (38)

A Y (yes) reply here implies a new output file, so that a new output file will be requested at step (3). However all requests f-- variable names by steps (6) to (12) will not appear. The response at step (12) will appear as

ORDER OF XXX'S AS FOR THE LAST FILE (Y OR N) ? (39)

A Y (yes) reply will leave the values of XXX as for the previous data set. An N (no) reply wil bring the same response as for step (12). An N (no) reply to step (38) will begin again at step (2) as if the program had been restarted. If the reply to step (38) was Y, then

THE SAME SCALES (Y OR N) ? (40)

will be typed. A Y (yes) reply will maintain all scaling information as for the previous plot and hence all scaling requests, steps (18) to (22), will be omitted. An N (no) reply fixes the variables to be plotted but allows the input of new scaling factors.

The handling of heading information on the second and subsequent runs is somewhat different from that of the first run, so as to allow the retention of headings from one plot to the next. On such a run step (29) will be replaced by

RETAIN ALL NONE OR SOME LINES OF HEADING (A, N, OR S) ? (41)

A reply of A (all) retains all heading lines as before. A reply of N (none) expects all lines to be replaced and therefore step (30) is typed. A reply of S (some) produces

LINE N THE SAME (Y OR N) ? (42)

where N varies from 1 up to the maximum number of lines input on the last run through. A Y (yes) reply retains that line and the request is repeated for the next line. An N (no) reply produces

TYPE NEW LINE N (43)

and the new line may be typed in, again limited to 72 characters and ending with a CR/LF.

2.3 GENERAL OBSERVATIONS

Although it is basically possible to plot any of the seventeen variables against any other, with any variable as parameter, there remain presently several combinations which will not produce the desired results. Those which have been intentionally deleted (either for reasons of difficulty in programming or loss of accuracy) are:-

- all variables requiring slope calculation - DCLAL, DCZAL, DCLCM, DCNBT, DC1BT, DCYBT - plotted against any variable other than Mach number. A survey of published reports indicated that these variables have only ever been plotted against Mach number, so that this limitation should not be too restrictive.

- any combination of variables which would involve a double interpolation. For example, if data have been collected at constant angles of incidence, and the user requests a plot of pitching moment coefficient versus Mach number with lift coefficient held constant, this will in general require interpolation in Mach number to find constant Mach number and then interpolation in angle of incidence to find the required lift coefficient. Such double interpolations are of doubtful accuracy, and such cases are therefore deliberately excluded.

The user is warned that not all combinations (there are over 4000 possible combinations of variables) have been fully tested. He may be sure however that all of the commonly used forms have been checked and found to give no trouble. If unusual combinations of variables are specified the user should check that the output is as he would expect it to be.

The user is also warned of the pitfalls involved in the slope finding algorithms used by the program. As indicated above the option of whether to use least squares straight line or exact piecewise cubic polynomial fitting to determine slopes is left open to the user. Experience has shown that where the data fall generally on a straight line but with some scatter, the straight line option is, as would be expected, the better. For this type of data the piecewise cubic can produce quite meaningless results. The cubic polynomial does give good results over a wide range of data where the existence of a straight line correlation is not expected. However, the user is urged to carefully check plots of derivatives to ensure that the results are meaningfull.

Turning to the subject of scales, the algorithm employed for automatic scale selection has proved extremely reliable and no cases have been found for which it failed. When using the manual scaling facilities, it is the user's responsibility to ensure that the scales specified are suitable for the range covered by the data being plotted. Any points lying outside the horizontal axis length (across the plotting paper) will be lost. However, in the vertical axis direction there is no similar facility, and the ultimate limit is provided by the PDP-10 system plotting software, where, if a point extends more than 12 feet in the vertical axis direction (along the paper) an error message

    LU 1 X GT 12'

will be printed and execution will be terminated.

3. PROGRAM INTEG

3.1 INTRODUCTION

INTEG is a program for the reduction of two-dimensional aerofoil surface pressure data to integrated force coefficient form. The program produces output files suitable for the production of listings of the data and integrated coefficients in a form suitable for publication (see Figure 3). It also produces an intermediate output file which may be used as input to the pressure data plotting program PLTALL (see section 4.). Integration of pressure coefficient with respect to non-dimensional position is carried out by an exact piecewise cubic polynomial curve fitting routine, with slope averaging at each point [7] . The program always produces lift and pitching moment coefficients (integration with respect to non-dimensional chordwise position), and optionally drag coefficient and the contribution of drag to pitching moment coefficient (integration with respect to non-dimensional normal coordinate). The routine used to perform the integration gives the user the opportunity to provide information gained from his aerodynamic experience, such as the generation of reasonable values of leading- and trailing-edge pressures if no measurements exist, or restrictions on the shape and/or boundedness of the fitted curve. This aids the production of integrated values similar to those which would be obtained from the application of aerodynamic experience if the integrations were performed manually. This information is built into the program as a default set of parameters suitable for application to the type of pressure distribution usually encountered, but this default set may be optionally changed by the user.

The operation of the program may be conveniently split into two sections. The first involves setting up program parameters, data tables, headings, etc. to tailor program operation to the requirements of the users particular data. The second section involves the actual processing of the data, where the user supplies input and output file names.

The formats required for input data files and data tables are given in Appendix A. The simplest method of generating input data files of a suitable format is to transfer pressure data generated by the tunnel system from a PDP-8 format DECtape to a PDP-10 format DECtape using POUT and CP10. [6]

The following guide to running the program reflects the software as at March 1980.

3.2 RUNNING THE PROGRAM

Assuming that a version of the file INTEG.EXE is resident on the user's disk area (if not, a version may be obtained from DECtape D/868) the program is started by the command

RU INTEG

The program then types the heading

TRANSONIC TUNNEL PRESSURE DATA INTEGRATING PROGRAM (1)#3

#3Numbers in brackets refer to the step numbers.

The program then enquires whether the input of up to five heading lines which will be printed at the top of each page of the listings file is required.

ARE HEADINGS REQUIRED (Y OR N) ? (2)

An N (no) reply proceeds to step (4). If a Y (yes) reply is received the program types:

TYPE IN UP TO 5 LINES OF UP TO 72 CHARACTERS EACH
FIRST CHARACTER OF LAST LINE AN ^ (3)

Each line typed in should be ended with a CR/LF. Note that no more than three consecutive blank characters should appear since the program uses such a string to recognise the end of valid information on a line. The ^ (up arrow) should be the first character of the line following the last line of text required, and should be followed by a CR/LF. The ^ is not required if all five input lines are used. For step (2), as in all multiple choice questions, a reply of any character other than those given in brackets (in this case Y or N) will cause the question to be repeated. The program then types

DO YOU REQUIRE DRAG INTEGRATIONS (Y OR N) ? (4)

A Y (yes) reply indicates that the program should carry out integrations for drag coefficient and the contribution of drag coefficient to pitching moment coefficient. The user should be careful to ensure that the distribution of data (pressure holes) is sufficiently fine near the leading edge to justify such integrations. An N (no) reply will delete these integrations. The program then types

TYPE HOLE LOCATION TABLE FILE NAME : (5)

and expects a valid PDP-10 file name consisting of a 1 to 6 character file name optionally followed by a full stop (".") and a 1 to 3 character extension. This file should contain a table of nondimensional chordwise positions (x/c) at which the data were recorded (i.e. the location of the pressure holes). If step (4) was answered with a Y, this file must also include a table of non-dimensional normal coordinate (y/c) values. The format required for this file is given in Appendix A. The program then types

DO YOU WANT A DEFAULT PARAMETER SET
FOR LIFT/PITCH (Y OR N) ? (6)

A Y (yes) reply will retain the default parameter settings and jump to step (10) or (14). An N (no) reply will produce

TYPE IN NEW PARAMETERS (NAMELIST FORMAT) (7)

which expects the parameters (listed below) to be input in NAMELIST [8] input format. This format consists of a $ (ALT MODE) followed by the list name - in this case LIFT - followed by parameter definitions, separated by commas, and completed by a further ALT MODE. For example

```
$LIFT KL(1)=1,KL(3)=2,KL(6)=28 $
```

Note that only those parameters which differ from their default values need to be included in the list. If variables other than those of the LIFT list are included, an errror message will be printed and execution will be terminated. The LIFT list parameters are KL(J) where

J varies from 1 to 11, and ICHAN. These parameters and their default values are defined as follows:-

KL(1-5) Straight Line Fits - an integer I inserted into any of KL(1) to KL(5) results in a straight line being fitted between point I and I+1. At points I and I+1 there will thus be a discontinuity in both slope and curvature. Point numbering begins at the trailing edge point (real or generated) on the lower surface and continues clockwise around the aerofoil, including the leading edge point (real or generated) to the trailing edge point (real or generated) on the upper surface. Values not used should be left equal to zero. Default values: If a trailing edge point is not input; KL(1)=1, KL(2)=N, where N is the number of the last point on the upper surface (i.e. the total number of pressure holes). If a trailing edge point is input; KL(1)=KL(2)=0. In both cases KL(3) to KL(5)=0.

KL(6) Leading Edge Treatment - An integer I inserted into KL(6) indicates that this point is to be generated as a leading edge point by parabolic extrapolation from upper and lower surfaces. Default Value : If a leading edge point is not input, KL(6)=NLS+1, where NLS is the number of pressure holes on the lower surface. If a leading edge point is input KL(6)=0.

KL(7-8) Vertical Tangents - An integer I inserted into either KL(7) or KL(8) will result in a vertical slope being specified at point I. This facility is useful in avoiding problems with the fitted curve passing outside the bounds of the figure. Default Values: KL(7)=KL(8)=0.

KL(9-10) Non-rotation of Axes - To cope with the situation where multiple ordinate values are generated by the integrating routines axes rotaion algorithms [7], an integer I is is inserted into KL(9) and/or KL(10) to generate the fitted curve between points I and I+1 in the original axes system. Default Values: KL(9)=KL(10)=0

KL(11) Non Monotonicity Test - If KL(11) is set to unity, the routine will check that the fitted curve between each pair of points lies wholly within the abscissa values of these points. If this is not the case, modification of the fitted curve is attempted, with final resort to a straight line. Default Value: KL(11)=0.

ICHAN Output of Fitted Curve - If ICHAN is set to other than zero a table of coordinates of the fitted curve will be output to the intermediate file to enable later plotting. Default Value: ICHAN=0

Following successful input of the LIFT list parameters, the program will type

LIFT PARAMETERS ARE: (8)

followed by a list of the present values of all LIFT list parameters and completed with

OK (Y OR N) ? (9)

An N (no) reply return to step (7). A Y (yes) reply will continue with either step (14) or, if drag integrations are to be carried out

DO YOU WANT A DEFAULT PARAMETER SET
FOR DRAG (Y OR N) ? (10)

Once again a Y (yes) reply will retain DRAG list default parameter settings and continue at step (15). An N (no) reply will produce

TYPE IN NEW PARAMETERS (NAMELIST FORMAT) (11)

which expects a similar input to that for step (7). The DRAG list parameters are KD(J) where J varies from 1 to 11 and each element has the same effect as the KL's of the LIFT list. The default settings for the DRAG list parameters are the same as for the LIFT list, except that KD(6)=0 and the same value of pressure coefficient as that found for the lift integration is used for the leading edge point. Also the parameter ICHAN is not included since no fitted curve data is required.

The program will then type out the DRAG list parameters, headed by

DRAG PARAMETERS ARE: (11)

followed by

OK (Y OR N) ? (13)

and the replies have the same effect as those for step (9).

The output of a file suitable for listing on the line printer may be optionally included by a Y (yes) reply to

PRODUCE LISTINGS FILE (Y OR N) ? (14)

An N (no) reply will transfer to step (16). If values of wake drag are to be input to the program for inclusion on the listings, provision must be made at this preliminary stage. Accordingly the program types

ARE WAKE DRAG VALUES TO BE INPUT (Y OR N) ? (15)

A Y (yes) reply will include provision for input of wake drag values at step (19).

The preliminary section of the program is now complete, the program's parameters having been set. The remaining section involves the input and output of data sets to be integrated. The program therefore asks for a file name for an output listing file, if this option has been retained at step (14).

TYPE OUTPUT (LISTINGS) FILE NAME : (16)

where any valid PDP-10 file name will be accepted. This is followed by

TYPE OUTPUT (STORAGE) FILE NAME : (17)

which once again expects a valid PDP-10 file name. This output file will contain the input data, integrated coefficients, wake drag values if these are input, and if requested (ICHAN ≠ 0), interpolated fitted curve coordinates, in a form suitable for later input to the pressure data plotting program PLTALL (see section 4.). Next, the program types

TYPE INPUT (DATA) FILE NAME : (18)

and a valid PDP-10 file name of the file containing the input data is expected. This file may contain any number of data sets in the format given in Appendix A. Processing of data sets will continue until an end of file marker is encountered. Any illegal character encountered in the input file will cause the job to be terminated and the line containing the offending character to be printed on the terminal. An up-arrow (^) will indicate the position of the illegal character.

If wake drag data is to be input, then for each set of data read from the input file, the program will type

CDW = (19)

and expects a signed decimal floating point number with up to four decimal places.

After reaching an end of file mark on the input file, the program closes both output files and types

ANOTHER INPUT FILE (Y OR N) ? (20)

A Y (yes) reply returns to step (16) or (17). An N (no) reply will terminate execution.

Listings files may now be printed on the line printer using the print queue in the normal way (print with a /P option), and the storage file may be used as input to the program PLTALL to produce plotted output.

4. PROGRAM PLTALL

4.1 INTRODUCTION

This program is intended to plot pressure data generated from either experimental or theoretical sources in the form P/H and/or Cp versus x/c. The program is presently set up to read input data generated the pressure data integration program INTEG (see Section 3.) or from some particular theoretical pressure distribution generating programs. The input data formats implemented at present are given in Appendix A. These may be changed by the user to suit other theoretical data sources. The easiest way to produce experimental data files of suitable format is by means of the program INTEG.

The program plots theoretical data as a continuous interpolated curve, optionally with symbols marking every third point, the symbols for upper and lower surfaces being different. For experimental data, only the symbols marking the data points are plotted, again with different symbols for upper and lower surfaces. Optionally, if a set of fitted coordinates is available, for example as may be produced by INTEG with ICHAN#0, a continuous curve may be plotted through these points. The program has the ability to plot up to five sets of data (either experimental and/or theoretical) on each set of axes, with different symbols for each set. Labels identifying each data set and its corresponding set of symbols may be added by the user. An example of the plotted output of the program is illustrated in Figure 4.

The following program running instructions reflect the software in existence in March 1980.

4.2 RUNNING THE PROGRAM

Assuming that the file PLTALL.EXE is resident on the user's disk area (if not a version may be obtained from DECtape D/868) the program may be started by the command

RU PLTALL

The program begins by typing the heading

TRANSONIC TUNNEL PRESSURE DATA PLOTTING PROGRAM (1)#4

The program then requests an output file name

TYPE OUTPUT (PLOT) FILE NAME : (2)

and expects a valid PDP-10 file name consisting of a 1 to 6 character file name followed optionally by a full stop (".") and a 1 to 3 character extension. This file will recieve the outut plotting file. The program then types

PLOT P/H OR CP OR END (P/H, CP OR END) ? (3)

#4Numbers in brackets refer to step numbers

A reply of P/H or CP indicates that data should be plotted as P/H versus x/c or Cp versus x/c respectively. A reply of END indicates that no further output is required on the present output file, the output file is closed, and the program transfers to step (12). As for all multiple answer requests, a reply of any character combination other than those indicated (in this case P/H, CP or END) will cause the request to be repeated. The program then types

TYPE KIND OF INPUT FILE (TH, EX OR END) ? (4)

where a response of TH indicates that the program should expect an input file generated by a theoretical program and EX an experimental data file generated by INTEG. A reply of END indicates that no more plotting is to be done on the current set of axes, and the program jumps to step (3). If the reply was TH, the program then asks

2D OR AXISYMMETRIC OUTPUT (2D OR AX) ? (5)

The user should then indicate the type of theoretical program which produced the input file.

The program then requests the name of the file from which the data to be plotted is to be obtained.

TYPE INPUT DATA FILE NAME : (6)

where once again any valid PDP-10 file name is expected. This is followed by

TYPE NUMBER OF SETS OF DATA : (7)

which expects an unsigned decimal integer N. The value of N specified should include the number of data sets in the input file up to and including the last one required to be plotted, even if some of the intervening files are not required (see step (9)). The number of individual files plotted on the one set of axes is limited by the number of symbol table entries and the space available for printed legends and integrated coefficients to five, although the value of N is strictly unlimited. The program then types

SET 1 (8)

SYMBOL = (9)

and expects an unsigned decimal integer I. The value of I controls

the plotting symbols used etc. according to the following table:-

I	Action or Symbol plotted — Upper Surface	Action or Symbol plotted — Lower Surface
0	Jump to next data set - do not plot	
1	Plot with solid line only - no symbols	
2	cross	plus
3	triangle-up	triangle-down
4	diamond	square
5	triad	asterisk

I=0 is used for jumping over unwanted data sets in the input file without plotting them. For I=2 to 5, theoretical files will be plotted with a continuous line, every third point being marked by a symbol. Experimental files will be plotted with a symbol at each data point with a continuous interpolated line if this was requested at step (5). At this point the user is given the opportunity to label each set plotted, the label being printed beside the symbols used for each plot. The program will type

TYPE LABEL FOR THIS SET (MAX. OF 75 CHARS.) (10)

and up to 75 alphanumeric characters may be entered, ending with a carriage return. Characters after the 75th will be lost.

The program then reads in data as required and carries out axis drawing and data plotting specified. If the reply to step (4) was EX, the program will scan the input data to determine whether interpolated data coordinates are present. If such data are found, the program will type

PLOT INTERPOLATED CURVE (Y OR N) ? (11)

and a Y (yes) reply will produce a interpolated curve through the data points. Note that this is the default action when plotting theoretical files so that step (11) will not appear.

If at any time during data input an end of file is encountered, the program types

END OF FILE ENCOUNTERED IN FNAME.EXT
TRY AGAIN

where FNAME.EXT is the filename input at step (6). The program will then return to step (6) to allow the user to correct the error.

Steps (9), (10) and (11) are then repeated for each set of data up to the number N specified at step (7). The program then returns to step (4) to allow the user to include data sets from other input files on the

present plot. When all required data sets have been plotted, the user types END to step (4), and a new set of axes may then be specified at step (3). If all output to the current output file has been completed, the user types END to step (3) and the program responds with

FINISHED (Y OR N) ? (12)

At this stage the output file will be closed and the user may open a new output file by typing N (no) which transfers to step (2). If all plotting has been completed, the user types Y (yes) and the execution of the program is terminated.

The output files may then be plotted up using the PDP-10 system program PLOTQ described in Appendix B.

APPENDIX A

Input Data Formats

(a) Program PLT8

This program has been designed to accept input data in the format produced by the program FOUT [6]. FOUT takes computed data produced by the PDP-8/I six-component force program 6END and packs the data as ASCII characters, without decimal points, in a line structure identical to that produced by 6END on the tunnel line printer. Thus the order of the variables in a line is: serial number, Reynolds number, Mach number, angle of incidence (sine definition), lift, pitching moment, drag, normal force, and axial force coefficients, lift coefficient squared, base force coefficient, alternate angle of incidence (tangent definition), angle of side slip, cross wind force, yawing moment, and rolling moment coefficients, roll angle and side force coefficient. For all except serial number (which is an integer), Reynolds number and Mach number (which are invariably positive), signs are inserted as required. Thus each line of the input file is read in under a FORTRAN [8] format statement

```
FORMAT(I3,2F4.3,7F6.4,2F5.2,3F6.4,F5.1,F6.4)
```

(b) Program INTEG

(i) Pressure Hole Location File.

This file should contain a table of non-dimensional coordinates of the positions of the pressure holes on the aerofoil. The first line of the file should contain two integers, N and NLS, in format 2I3, where N is the total number of actual (not generated) pressure holes on the aerofoil surface, and NLS is the number of pressure holes on the lower surface including the trailing edge hole, but not the leading edge hole, if either exist. The following N lines should contain the coordinate pairs in the order x/c, y/c, one pair per line in a format 2F10.3. The first coordinate pair should correspond to the pressure hole at, or closest to the trailing edge on the lower surface, and the order of coordinate pairs should continue clockwise around the aerofoil to those of the hole closest to the trailing edge on the upper surface. Each hole position should only be included once - i.e. the first data point (the trailing edge point if it exists) should not be repeated at the end of the data. If no drag integrations are required, the normal coordinates (y/c) may be omitted.

(ii) Input Data File

INTEG has been written to accept input data in the format produced by the program POUT [6]. POUT takes pressure data generated by the PDP-8/I

pressure measurement program and converts them to a string of ASCII characters without decimal points. The first line of a data set will contain the variables: serial number, free stream static pressure (Po), free stream total pressure (Ho), Mach number, angle of incidence, roll angle, temperature and Reynolds number. Angle of incidence and roll angle will have signs inserted as required. This first line is read by a FORTRAN *format statement*

```
FORMAT(I3,2F4.3,F5.3,F5.2,F5.1,F3.1,F4.3)
```

Second and subsequent lines will each contain eleven pairs of P/H and Cp values, the number of lines being sufficient to contain all the data. These lines are read in under a format statement

```
FORMAT(11(F4.3,F5.3))
```

and reading continues until N (the number of pressure holes specified in the hole location file) pairs of variables have been obtained.

(c) Program PLTALL

(i) Experimental Input Files

PLTALL has been written to take as input the intermediate file output by the program INTEG. This file will consist of, on the first line, two integers N1 and N2, where N1 is the number of experimental data points, and N2 is the number of interpolated data points. If no interpoltated data are present, INTEG sets N2 to zero, and PLTALL takes this as a signal that no interpolated data are available. The format for N1 and N2 is 2I3. The following N1 lines contain sets of values of x/c, Cp and P/H in that order, one set per line, in format 3F10.5. The next N2 lines (if N2>0) contain values of the same variables for the interpolated curve, again in format 3F10.5. The last line of each data set contains the variables: Mach number, angle of attack, Reynolds number,and integrated lift,pitching moment, and drag coefficients. (Drag coefficient will be set equal to zero by INTEG if no drag integration were carried out, and such values are not included by PLTALL in the output file).This last line is read in under a format of 6F10.5.

(ii) Theoretical Input Files.

Theoretical input files have much the same format as experimental files, with the exception that no experimental data exists or is included. The first line contains an integer N equal to the number of data points, followed by N lines with values of x/c, y/c, Cp and P/H on each line. The formats for these lines is once again I3 (first line) and 4F10.5 (subsequent lines). The last line contains various parameters output by the theoretical programs and is read in under a suitable format.

APPENDIX B

Sending Files to the Plot Queue

Plot files which have been produced by the programs PLT8 and PLTALL will reside on the user's disk area in a binary form which is only intelligible to the PDP-10 system program PLOTQ. This is a program which takes plot files, decodes them, and transfers them to the plot queue area ([4,1]) of the disk for plotting on one of the system plotters. The program PLOTQ is initialized by the command

.R PLOTQ

and the program will reply with the time of day followed by an asterisk (*) to indicate it's readiness to recieve a command, thus

09:30 *

Commands are of the form

filename1.ext,filename2.ext,........,filenameN.ext CR

where filename1.ext etc. are the files the user wishes to have plotted. The program will then type

```
FILES PLOTTED        REQUEST FEET           LIMITS
filename1.ext          R N     Z      2.53",1'04.60"; -5.43",5.47"
```

where R N indicates that this file is the Nth file the user currently has in the queue waiting to be plotted; Z is the number of feet occupied by the file in the X (drum) direction; and LIMITS are the actual maximum and minimum excursions of the plot in the X and Y directions respectively. Similar lines will appear for each file included in the command string.

A useful final command to the program when all files to be plotted have been input, is the /S command in the form

* /S $

where $ is an ALT MODE . This will produce an output line giving the status of the plot queue in the form

STATUS JXX R N 09.30

where JXX is the job number of the user whose Nth request is currently being plotted and 09.30 is the time of day at which that job was entered into the plot queue. This therefore gives some indication of how far behind the present time the plot queue is currently running. The user's job number is contained in the message printed on the terminal when logging in, or it may be ascertained by typing

. PJ

when in monitor mode. Exit from the program is achieved by ending a command with an $ (ALT MODE) rather than a carriage return, as shown in the status command above, or by typing a ^C (control C) as a response to the asterisk printed by the program.

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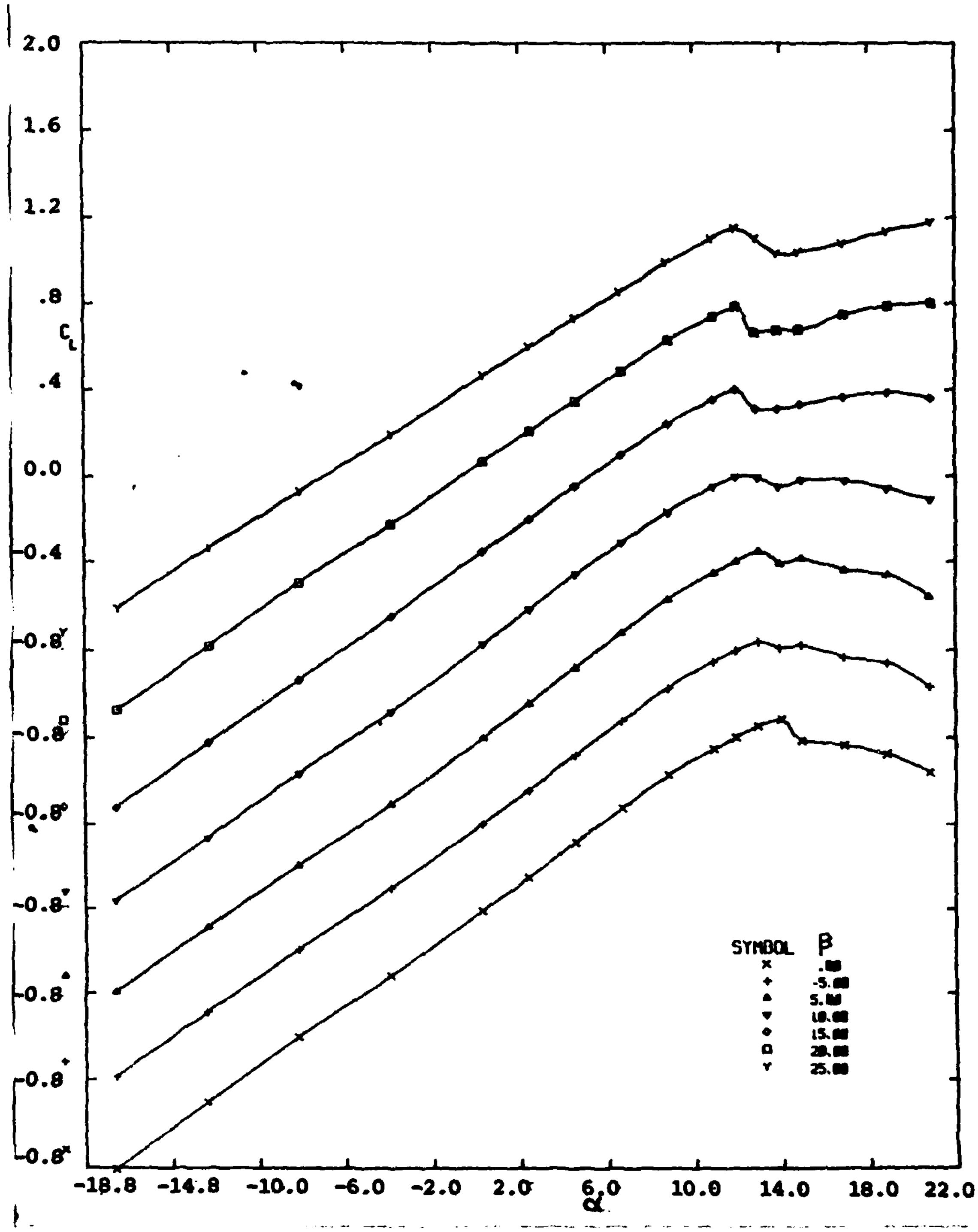

FIG.1 TYPICAL PLOTTED OUTPUT FROM PLT8 - WITHOUT 1" GRID

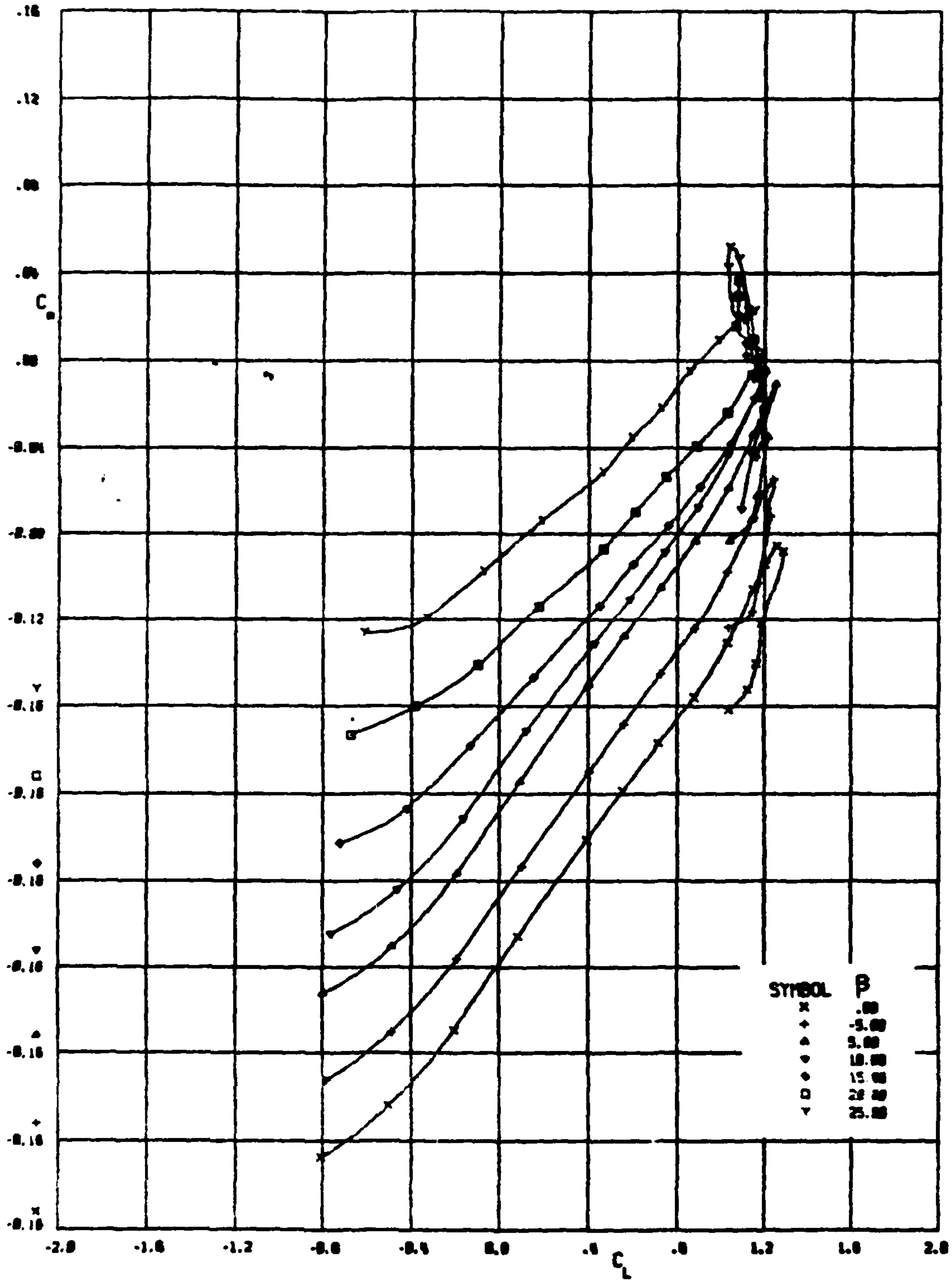

FIG.2 TYPICAL PLOTTED OUTPUT FROM PLT8 - WITH 1" GRID

BGK 1 - 4" CHORD

EXPERIMENTAL PRESSURE DISTRIBUTION

MACH NO. 0.805 ALPHA 1.40 REY $0.77*10^{6}$

INTEGRATED FORCE COEFFICIENTS

CL = 0.3819 CD = 0.0165 CM = -0.0899

UPPER SURFACE VALUES			LOWER SURFACE VALUES		
X	CP	P/H	X	CP	P/H
0.0000	1.149	0.993	0,0000	1.149	0.993
0.0089	0.315	0.746	0,0096	0.529	0.809
0.0206	-0.029	0.644	0,0205	0.088	0.678
0.0306	-0.204	0.591	0,0306	-0.017	0.647
0.0504	-0.324	0.556	0,0506	-0.054	0.636
0.0752	-0.683	0.449	0,0754	-0.284	0.567
0.0999	-0.828	0.406	0,1001	-0.307	0.560
0.1252	-0.897	0.386	0,2000	-0.529	0.495
0.1599	-0.839	0.403	0,2496	-0.515	0.499
0.2300	-0.824	0.408	0,3495	-0.508	0.501
0.2407	-0.801	0.415	0,4486	-0.287	0.566
0.2798	-0.801	0.415	0,5493	-0.120	0.616
0.3202	-0.809	0.413	0,6499	0.058	0.669
0.3603	-0.825	0.408	0,7499	0.214	0.715
0.4001	-0.842	0.403	0,8500	0.271	0.732
0.4198	-0.845	0.402			
0.4402	-0.849	0.401			
0.4599	-0.850	0.400			
0.4796	-0.863	0.397			
0.4996	-0.883	0.391			
0.5405	-0.891	0.389			
0.5602	-0.894	0.388			
0.5803	-0.834	0.406			
[illegible]	-0.674	[illegible]			
0.6203	-0.499	0.505			
0.6505	-0.371	0.543			
0.6754	-0.316	0.559			
0.7005	[illegible]	0.574			
0.7255	-0.226	0.586			
0.7504	-0.183	0.598			
0.7753	-0.150	0.608			
0.8005	-0.114	0.618			
0.8255	-0.087	0.626			
0.8503	-0.060	0.634			

FIG.3 TYPICAL DATA LISTING FROM INTEG.

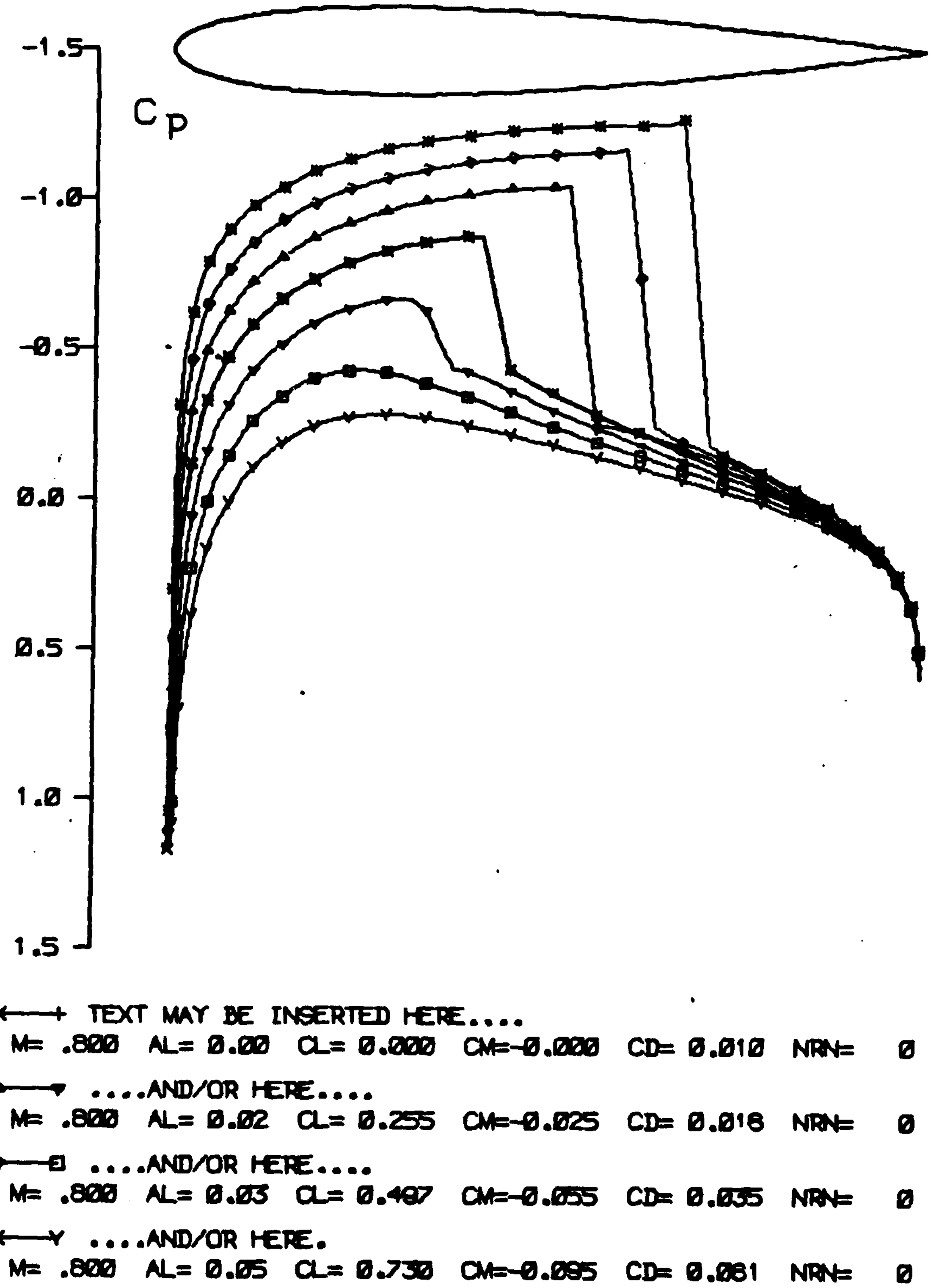

FIG.4 TYPICAL PLOTTED OUTPUT FROM PLTALL

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